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Towards Integrated Modeling of Business Processes and Business Rules

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Abstract

While business process models describe business operations in a procedural form, business rules are typically expressed in a declarative fashion. Previous studies have demonstrated that both approaches are complementary as they address distinct aspects of organizational practices. However, both approaches share areas of overlap that allow for the linkage of rule bases and process models. Current technology offerings allow for the pragmatic invocation of rule engines from business process management systems, but an integrated procedure model is lacking that guides modelers when to model organizational aspects as rules or processes and in which order to develop the separate artifacts. The research presented here aims to address this gap by presenting a decision framework for process and rule modeling, and an initial procedure model for integrated modeling with the two approaches.

Keywords

Business process modeling, business rule modeling, business process management, procedure model

INTRODUCTION

Managing and improving processes has been named the number one priority of CIOs for five years in a row (Gartner Group, 2005; 2006; 2007; 2008). The renewed focus on organizational processes is motivated by two objectives. On the one hand, economic conditions force organizations to continually search for ways to increase the efficiency of their operations, which is achieved through the reengineering and streamlining of processes with a focus on performance. On the other hand, the increased complexity of the extended enterprise, through new technologies and cross-enterprise information systems, forces organizations to maintain standardized operations and realize economies of scale. To this end, many organizations turn to industry best practices and reference models in areas that do not constitute a competitive advantage.

In a similar fashion, the documentation and enforcement of business rules has gained interest in recent years for two reasons. On the one hand, increasing regulatory oversight in the wake of corporate scandals and compliance and privacy breaches has led organizations to define clear constraints under which they can operate. This area of concern is called Governance, Risk and Compliance (GRC). To document and enforce these constraints, many organizations are using Business Rules Engines. On the other hand, organizations are interested in enabling flexibility in their information systems infrastructure through the automated evaluation of its business context (e.g., market conditions or environmental data) and the subsequent initiation of actions that are appropriate in the detected context. This increased interest leads to the development of automated sense-and-respond operations and helps in the streamlining of decision-making. Software that provides support for decision trees and automated reasoning is applied in these circumstances.

Both Business Process Management and Business Rule Management are thus approaches that focus on the improvement of organizational efficiency and effectiveness, but as technologies they have evolved separately. There are few examples of integrated systems. For example, Pegasystems' Pega Rules Process Commander product natively combines a sophisticated business rules development environment with a business process modeling context (Pegasystem Inc., 2008). Other Business Process Management System vendors have partnered with or acquired Business Rules technology vendors to complement their process management capabilities with the ability to document rules. In the other direction, however, Business Rules Engines vendors have made little attempts at adding process support to their products, which supports the view that processes may serve as the primary integration vehicle in this context.

At the conceptual level, the Business Process Modeling Notation represents an emerging standard for the graphical documentation of processes (OMG, 2008). It contains several symbols that represent integration points between a graphical process and a rule base: A complex gateway can be employed to reflect the use of business rules to determine branching conditions in a process. A rules event can be used to reflect the reaction to a particular condition, akin to Event-Condition-Action (ECA) rules. However, the BPMN specification does not provide any guidance as to how these rules could be identified or captured. The lack of guidance is confirmed in practice, with a recent empirical study finding that organizations have difficulties in adequately modeling business rules with BPMN (Recker *et al.*, 2006).

In summary, while rules and processes address related organizational concerns, their documentation and enforcement are treated as largely separate subjects. What is missing is an integrated procedure model that allows business analysts to simultaneously address rules and processes, separate them where necessary and re-integrate them where appropriate. The work presented in this paper addresses this area in that it presents a decision framework for the modeling of various aspects as either business rules or business process elements, and an initial procedure model for the integrated modeling of rules and processes.

The remainder of this paper is structured as follows: In the next section we compare and contrast business process-oriented and business rule-oriented approaches to organizational modeling, and present related work on the integration of the two approaches. The following section presents a decision framework that can be used to guide the choice of modeling an organizational aspect as either a business rule or a business process component. Given that a modeling scenario is likely to incorporate both business rules and business process components, next, we present consolidated guidelines for process and rule modeling, followed by the procedure model for integrated business process and business rule modeling in the subsequent section. We conclude the paper with a summary, a discussion of limitations and an outlook on future work.

RELATED WORK

While, to our knowledge, no procedural guidelines for the integration of rule- and process-based modeling approaches have been published, our research in this area is informed by a number of related fields. Accordingly, in the following subsections we present a discussion of business rules, business processes, and existing attempts at their integration, as well as published guidelines for the two modeling approaches.

Business Rules

A business rule is a statement that aims to influence or guide behavior and information in an organization (Steinke and Nikolette, 2003). The Semantics of Business, Vocabulary and Rules standard of the Object Management Group distinguishes between structural and operational business rules (OMG, 2006). While structural rules are used to express relationships and constraints among data elements, operational rules are used to guide and constrain the behavior of individuals. Two examples for structural rules are integrity and derivation rules (Wagner, 2005). *Integrity rules* express constraints and define the acceptable relationship between data elements. For example: each order must contain at least one line item. *Derivation rules* define the validity of facts and can be used to infer new facts based on known facts. For example: A customer with an annual order volume of more than $250,000 is a frequent buyer. John Doe has ordered products worth $300,000. As a conclusion, John Doe is a frequent buyer.

Examples of operational rules are reaction rules, production rules, and transformation rules (Wagner, 2005). *Reaction rules* (aka ECA rules) specify a trigger that activates the evaluation of the rule, a condition that is evaluated, and a subsequent activity that will be carried out if the specified condition is met; For example: On receipt of an invoice the amount of the invoice is evaluated. If the invoice amount is more than $5,000 a manager has to review it. *Production rules* (also known as condition, action rules) are similar to reaction rules, but do not specify a particular circumstance in which the evaluation takes place; For example: if there are no defects in the last 10 widgets, the entire batch is quality approved. *Transformation rules* restrict the state changes of objects; For example, an employee’s age can change from 30 to 31, but not from 31 to 30.

Business rule modeling languages are typically based on formal logic and have strong and precise expressive power (McBrien and Seltveit, 1995). In general, they belong to the declarative modeling category in that they focus on specifying what is required to take place, rather than how something is accomplished.

Business Processes

Business Processes are logically ordered sets of activities that produce a result of value to the customer. The modeling, execution (including automation), and evaluation of processes is summarized in the term Business Process Management. Process models are constructed using modeling grammars or languages (also referred to as techniques or notations). Most of these languages represent processes as procedural models, in that they focus on specifying the step-by-step activities that are required to take place in order to perform an action or achieve a desired outcome. Some authors further distinguish between process representations as scripts (e.g. tightly prescribed) and maps (e.g. loosely specified) (Schmidt, 1999). Process modeling languages provide a set of primitives (modeling constructs) and a set of construction rules that governs the use and permissible combination of the primitives.

Process modeling languages or grammars can be classified according to their focal modeling construct. *Activity-centered* process modeling languages represent processes as a network of tasks or activities that are linked through control- or data-flow connectors. This is the dominant type of process modeling representation in practice. *Process-object-centered* approaches specify processes as the permissible sequence of state changes of the process object (Ryndina *et al.*, 2007). *Resource-centered* process modeling languages represent processes as networks of processing stations (human and/or technical) that interact with each other.

Business Process and Rule Integration

Early work on the integration of business rules and business processes appeared shortly after the introduction of the rule modeling concept (Kappel *et al.*, 1998; Knolmayer *et al.*, 2000). Krogstie *et al.* (1991) were the first to suggest that business process and rule modeling approaches should be merged to improve the capture of temporal information for information systems development. They presented a top-down approach for model specification that involves the use of the External Rule Language (ERL) for specification of process logic at the lowest level of decomposition. McBrien and Seltveit (1995) further enhanced this concept by defining the structure of rules within the process model. Knolmayer *et al.* (2000) refined process modeling and linked the resulting models to workflow execution through layers of Reaction Business Rules. Kappel *et al.* (1998) use Reaction Business Rules to model the coordination in workflow systems. Kovacic (2004) developed a meta-model that represents important business constructs (goal, process, activity and events) and technical constructs (data objects, software components, actions in Information Systems). He demonstrates how rules can link these two categories of constructs. Charfi and Mezini (2004) argue that business rules are often hard-coded into web services and proposes a hybrid approach of separating business processes and business rules. Meng *et al.* (2002) introduced a dynamic workflow management system for modeling and controlling the execution of inter-organizational business processes. The system uses an event- and rule-server to trigger business rules during the enactment of workflow processes in order to enforce business constraints and policies.

While the integration of rule and process modeling has been the subject of some investigation in the research community, anecdotal evidence shows that organizations struggle to effectively capture business processes and rules. In a recent study of the representational capabilities of the Business Process Modeling Notation (BPMN) we found that organizations frequently supplement their BPMN process models with textual annotations of business rules (Recker *et al.*, 2006). This practice introduces problems regarding the consistency, reuse, and enforcement of rules – problems that are acknowledged by some of the organizations using this technique.

The need to improve the representation of business rules within process model diagrams is apparent. Previous work by Recker *et al.* (2005) has identified a general lack among process modeling languages to adequately represent business rules. Similarly, Green and Rosemann (2002) found limitations with respect to modeling business rules in their BWW-based investigation of all five views of Architecture of Integrated Information Systems (ARIS), a popular enterprise architecture framework.

Rule modeling languages are likely candidates to fill such gaps. An earlier study by Herbst *et al.* (1994) suggests that rule specification languages should be considered as a potential addition to graphical representation languages when modeling for Information Systems (IS) design. While their analysis is not based on any formal framework, they suggest that many of the popular IS modeling techniques lack the ability to adequately represent business rules. The work of Rosemann *et al.* (2006) suggests that the same shortcomings exist in the process modeling domain, hence an integration of business rule and business process modeling approaches may help overcome these perceived short-comings. Accordingly, our research aims to fill this gap by proposing guidelines for the selection of the business process or business rule modeling approach, and an initial procedure model for the integration of the two modeling approaches.

Modeling Methodologies

There appears to be a general scarcity of published work that offers guidelines for process or rule modeling, with rule modeling guidance, in particular, almost nonexistent. This lack of guidance is manifested in Australian organizations, who identify it as one of the roadblocks in their BPM initiatives (Indulska *et al.*, 2006).

Among the available guidance, Becker *et al.* (2000) offers a framework that includes six guidelines of process modeling, *viz.* correctness, relevance, economic efficiency, clarity, comparability and systematic design. While some general process modeling guidelines are suggested within defined abstraction layers, the approach is high-level with little procedural guidelines. Turk and Vaishnavi (1999) present a six-dimensional framework of potential process modeling issues that can manifest in modeling initiatives, and a set of general principles for process modeling. The set of developed principles advocates top-down modeling, with the need to first create domain models before engaging in finer granularity modeling. Similarly, Raduescu *et al.* (2006) identify a framework of modeling issues apparent in large modeling projects. The study identifies the issues through an empirical approach, however, provides little guidance for modeling.

PROCESS AND RULE MODELING – A DECISION FRAMEWORK

The use of a procedure model for integrated business process and business rule modeling needs to be informed by a decision framework that guides the selection of a process or rule modeling approach for each organizational aspect that must be modeled in a given situation. For example, a modeler needs guidance to determine whether a decision is to be explicitly modeled in the process or whether it is to be specified as a business rule stored in a rule engine. Following such a choice, the modeler then requires guidance on how to integrate modeling of the various aspects through rules and business process elements. Accordingly, in this section, we explicate such a framework. While the framework still remains to be empirically verified, it is the first step towards providing concrete guidance on the selection of the two modeling approaches.

When deciding on a modeling approach for a given aspect in an organizational situation – e.g. a decision - a number of factors should be considered. Through literature analysis and our extensive experience with BPM projects in industry, we identify five factors that are expected to influence the selection of a modeling approach, *viz.* change frequency, implementation responsibility, understanding of implications, source of change, and scope. We discuss the five factors in more detail as follows, in an order that reflects their perceived importance and likely impact:

Change Frequency

The frequency of change within the business has the potential to affect the choice of the modeling approach. Changes can occur frequently (e.g. hourly, daily, weekly) or over more significant timeframes (e.g. monthly, annually, etc). Frequent changes require mechanisms that support easy modification and validation, while infrequent changes allow for a planned approach, possibly a change management project. Intuitively, situations that are susceptible to frequent changes should be modeled with a business rule approach, since it is easier to change the parameters of an individual rule than to change an implemented process. The implementation of process changes is generally more time consuming and tends affect both organizational and technical aspects (e.g. task assignments as well as application invocation). By contrast, a business rule can often be changed by business users, who (given the right tools) should be able to adjust firing conditions and parameters relatively quickly (Rosca *et al.*, 2002). Furthermore, a typical business scenario may involve significantly more rules than process steps, making changes at the rule level more likely than a change at the process level (compare (Huang and Stohr, 2007)).

Implementation Responsibility

In a related manner, implementation responsibility has the potential to impact the choice of modeling approach. As noted, business users generally have the configuration responsibility over business rules, whereas technical BPM staff or the IT department usually implements business processes (Leymann and Roller, 2000). While the configuration of business processes by end users is a frequent promise by tool vendors, field reports indicate that the responsibility for process changes is often delegated back to the IT department (Royce, 2007). Accordingly, the choice of modeling approach is likely to depend on the role of the person who will be responsible for modeling the change.

Understanding of Implications

Another decision criterion is how comprehensively the effect of a change is understood. This reflects the level of risk involved in a given change. For example, if a change in one department’s business practices is necessitated by a change in another department or by an external entity, and its effects cannot be safely predicted, the situation should be modeled as a business rule. The advantage of rule modeling in this situation is easier and faster implementation in case adjustments needs to be made. On the other hand, if the effect of a change can be predicted and is well understood, then the situation can be modeled as a process (subject to other factors within the decision framework).

Source of Change

Sources of change – internal or external – can also have input into the choice of modeling approach. Requirements defined by external agencies or regulatory bodies can be critical to the organization, while being outside the scope of their control. Particularly when the changes pertain to compliance with regulations, modeling such aspects as part of a business process ensures that an audit trail is created to facilitate demonstration of compliance in the event of an audit. On the other hand, internal changes, which are likely to also extend to other departments, can be modeled as business rules such that they can be reused and easily changed.

Scope

The scope deals with questions of what is influenced by the business change – whether the impact is focused on an activity, an entire process, department or the whole organization. Organization-wide changes are useful to model with the business rule modeling approach because the rules reside in a repository that can be accessed throughout the organization. Such modeling choice also prevents the analysis and change of a large number of processes that have embedded the aspects that require to be changed. In contrast, when a change occurs that focuses on a single activity, only one process requires modification (Kovacic and Groznik, 2004).

The five explicated factors, and their related decision spectrum, are represented in Figure 1. For example, when modeling an aspect of a process that is likely to change frequently (e.g. modeling a decision where the conditions change frequently), the preferred modeling choice is that of a business rule that can be easily updated in the rule repository rather than requiring a change in the parameters of a process model component.

The decision framework should serve as an indication and situations are possible where the framework will not yield a clear modeling approach choice. In such cases more information must be gathered to understand the unique organizational context within which the change is to occur.

	Business Rules				Business Processes
Frequency	Hourly	Daily	Weekly	Monthly	Annually
Implementation Responsibility	Business User	Business Analyst	Business / Systems Analyst	Systems Analyst	Programmer
Understanding of implications	Very Low	Low	Medium	High	Very High
Source of Change	Internal	Subdivisions	Divisions	Business Partners	External Agencies
Scope	Company-Wide	Multi-Process	Process	Activity	Within Activity

Figure 1. Modeling approach decision framework

GUIDELINES FOR PROCESS AND RULE SPECIFICATION

In the following sections we present guidelines for the modeling of processes, as well as guidelines for the modeling of business rules. The guidelines for process modeling are informed by a limited number of existing academic contributions in this field (see related work section), as well as by our practical experience. The guidelines for rule modeling have stronger roots in practice and are based on published high-level guidance since little academic work exists that suggests guidelines for business rule modeling. These guidelines should be used together with the decision framework introduced in the previous section. It is envisaged that the decision framework is used to identify the appropriate modeling approaches for each aspect of a situation to be modeled, and then the guidelines for integrated process and rule modeling are used to determine the order of modeling and the required activities.

The identification and analysis of business objectives forms the first stage of both process and rule modeling initiatives. The starting point for the modeling effort should, accordingly, be focused on developing an overview representation which contains only the main business activities of the organization (Madison, 2005). The rationale for starting at a high level of abstraction is to facilitate of a 'bird's eye view' of the organization – what are the major business activities, which entities are involved in performing these activities, what technical and human resources are associated with each activity, what are the desired outcomes, and what data is processed (Leymann and Roller, 2000).

Guidelines for Process Modeling

Once the business activities are identified (step 1), the next step in a process modeling approach is the systematic decomposition of key activities and their goals, while defining their exact boundaries. Each core business process can be analyzed to determine the individual components that ensure the attainment of the overall process goal. At this stage, a detailed description of the individual processes is created including their control flow (such as concurrent and alternative tasks), message exchanges, and organizational responsibilities. For most processes, the steps within the tactical process description can be broken down into individual activities. The documentation of the detailed process activities (sometimes called procedures) completes the final stage of process modeling. The result of this step is a set of operational process descriptions that are detailed enough for purposes such as training, decision-making, or root cause analysis.

	Stage I (Global) Key Business Objectives	**Stage II Core Processes**	**Stage III Business Processes**	**Stage IV Process Activities**
Activities	Identify key business objectives	Identify core processes	Decompose core processes into detailed processes	Specify process activity details
Challenges	Identification of all critical business objectives	Decision on what denotes a core process. Maintaining high level of abstraction. Defining process boundaries.	Identification of all processes contained in the core process. Maintaining a consistent level of abstraction.	In-depth understanding of process activities
Outcomes	Set of customer oriented enterprise activities and ranked business objectives	Set of high-level core process descriptions	Set of all processes related to the core process, modeled at a lower level of granularity	Set of detailed operational activities, including variants (where required)

Figure 2. Business process modeling stages

Guidelines for Rule Modeling

In a similar fashion to the guidelines for process modeling, figure 3 depicts the high level stages of business rules modeling in organizations. As discussed above, the first phase is in common with the process modeling approach. Beginning with key activities and goals, at the second stage the business rules modeler should identify key business objects that are manipulated in the organization's processes. An accurate understanding of business objects facilitates the identification of structural and operational rules that govern these objects and the activities that are performed to change their state. In order to establish a common vocabulary for the enterprise, key terms and definitions need to also be established in this step. This basic vocabulary covers all business objects of interest in the problem domain, naming conventions, and relationships among the business objects. Beginning with the business objects themselves, a modeler would first identify the core concepts of interest (i.e. nouns) and then define the relationships among these concepts (i.e. verbs). The outcome of this step is a structured vocabulary that can serve as the basis for further rule specification.

The next step in the methodology for rules development is the definition of structural rules that define and describe facts, constraints, and relationships that govern the data elements of the enterprise. These rules may include constraints for attribute values, cardinalities for linkages among objects, and inference rules that allow users to infer previously unknown facts from the existence of other facts. These structural rules provide the foundation for the subsequent definition of operational rules.

Constraints or rules that govern the behavior of resources (individuals and/or technical systems) can now be defined. These operational rules provide an understanding of all constraints that govern enterprise actions that are required to meet business objectives. This 'bird's eye view' of the constraints allows for the identification of potential missing or duplicate rules within the organization. Once such discrepancies are rectified the rules can be implemented using rules management systems at the lowest level of granularity. The specification of operational business rules, performed at the fourth and final stage of business rule modeling, results in a set of detailed, formally specified business rules, which are characterized by simple Boolean expressions and are detailed enough to be checked for inconsistencies.

	Stage I (Global) Key Business Objectives	**Stage II Business Objects, Terms and Definitions**	**Stage III Structural Rules**	**Stage IV Operational Rules**
Activities	Identify key business objectives	Identify core business objects and define core terminology of the enterprise	Document rules that govern the structure of business objects of the enterprise	Document rules that govern the behavior of resources in the enterprise
Challenges	Identification of all critical business objectives	Identification of business objects, removing homonyms and synonyms	Identification of relationships between data elements. Ensuring completeness.	Assessment of feasibility and impact of rules
Outcomes	Set of customer oriented enterprise activities and ranked business objectives	List of key business objects, Lexicon of key terms and definitions of the enterprise	A set of structural rules that define and constrain key data elements	A set of operational rules that define behavioral constraints and consequences

Figure 3. Business rules modeling stages

INTEGRATED METHODOLOGY FOR PROCESS AND RULE MODELING

Using the procedure models discussed above, we can now proceed to an integrated methodology for process and rule modeling, which is depicted in figure 4. As a first step, the key business objectives and activities should be identified. The key business objectives provide the context for the identification of core processes and business objects (and determination of their common vocabulary), which are subject of the second and third stages. The objects and their interactions provide input into stage 4, which is concerned with the identification of the structural rules that govern the objects. At the same time, the core process identification leads to the ability to model relevant business processes (stage 5). After stages 4 and 5 have been carried out, stage 6 enables the modeler to specify operational activities, before, finally, defining operational rules.

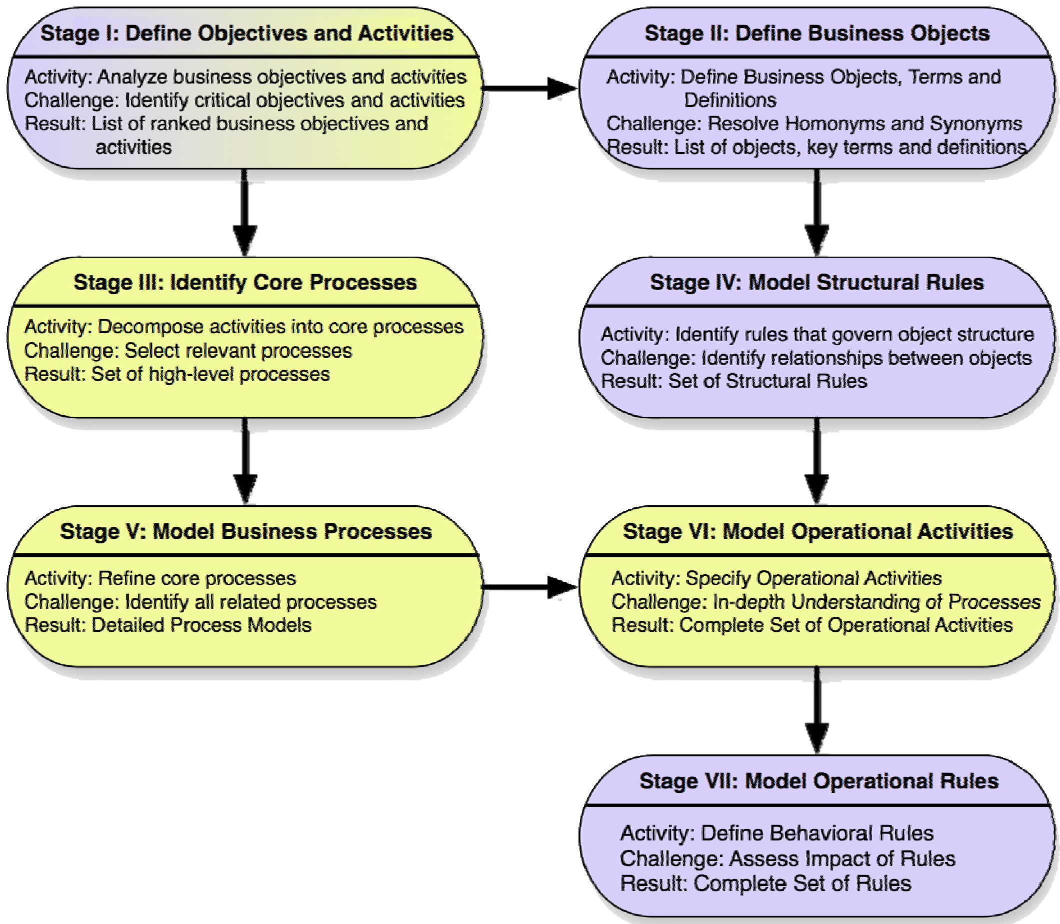

Figure 4. Integrated Procedure Model

CONCLUSION

Previous studies and anecdotal evidence suggest a need for an integrated procedure model that helps modelers decide when to model organizational aspects as rules or processes and in which order to develop the separate artifacts. This paper represents an early contribution towards advancing the integration of the business process and business rule modeling approaches. We present a decision framework for the selection of a process or rule modeling approach in a given organizational situation, and an initial high-level procedure model for the integrated modeling of business processes and business rules. The procedure model is based on modeling guidelines that are explicated from existing research, where available, and also our practical experience with process modeling projects in industry. The work is expected to be of relevance to both academia and industry. For the outlet of academia, the presented work provides a consolidation of existing research in this increasingly important area and an initial, though still untested, decision framework and procedure model for modeling business rules and business processes.

The main limitation of the work presented herein is the lack of validation of the decision framework and the procedure model. This work is planned as the next step in the research project and will involve industry participation in order to obtain feedback on and revise the decision framework and the integrated procedure model. As a first step we have begun to explore the use of complexity metrics as a benchmark for the usability of rule representations using SBVR and process representations using BPMN. Using a common business scenario we have modeled the scenario completely using a rules model, completely using a process model, and with various degrees of overlap. The different levels of measured complexity will help us provide more specific guidance as to where separating rules from processes will lower the cognitive effort required to understand the resulting models, and where relying on one representation over the other may lead to less understandable results.

Moreover, our focus thus far has been at a relatively high level of abstraction in order to provide an overall picture of the approach and facilitate initial discussion. We have not yet considered how business rule and business process modeling approaches might be integrated and visualized in a single model, and how these separate artifacts are to be kept synchronized. These aspects of our work are in their initial phases and will be pursued once validation of the model and framework is finalized.

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